

**UNITED STATES PATENT APPLICATION**

**APPARATUS AND METHOD FOR BRAILLE INSTRUCTION**

Inventor: Richard L. Goldberg  
Randal T. Cole  
Arielle Drummond  
Diane M. Brauner

Assignee: The University of North Carolina at Chapel Hill

Entity: Small

JENKINS, WILSON & TAYLOR, P.A.  
Suite 1400, University Tower  
3100 Tower Boulevard  
Durham, North Carolina 27707  
Telephone: 919-493-8000  
Facsimile: 919-419-0383

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Bonnie S. Sheridan  
Bonnie S. Sheridan

### Description

## APPARATUS AND METHOD FOR BRAILLE INSTRUCTION

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### Government Interest

This invention was made with Government support under Grant No. BES-9981867 awarded by the National Science Foundation. The Government has certain rights in the invention.

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### Technical Field

The present disclosure generally relates to instructing blind and visually impaired persons how to read and write Braille. More particularly, the present disclosure relates to an apparatus and method for facilitating the learning of Braille using tactile and auditory information.

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### Background Art

Braille is an essential tool of communication for blind and visually impaired persons. Generally, Braille is a system of writing in which each character is formed from a 3 X 2 (three rows and two columns) array or cell of  
20 Braille dots or points. Each character is distinguished by a specific pattern of raised and non-raised dots of the 3 X 2 cell. To enable blind and visually impaired persons to write in Braille in a manner similar to a typewriter, Braille

writers are commercially available that include a single-row, 1 X 6 keyboard, and often other input keys such as a space bar. Conceptually, the 1 X 6 keyboard corresponds to a 3 X 2 Braille cell, with the two columns of the cell rotated upwardly and outwardly away from each other to form the single, six-dot row. To form an imprint of a 3 X 2 Braille character on paper, the user of a Braille writer must simultaneously push the specific combination of keys of the keyboard that will cause the Braille writer to form the pattern of raised dots corresponding to the intended Braille character.

Unfortunately, the Braille system and the technique for using the Braille writer are difficult to learn, especially for preschool and elementary age children. It has been found that commercially available Braille training devices fail to engender sufficient interest for learning. As a result, children quickly become bored and require constant supervision when using conventional Braille learning tools. Many commercial Braille trainers, such as the popular swing cell instrument commonly used to teach Braille students how to read and write Braille, do not provide auditory feedback. A typical swing cell instrument includes two wooden arms that are either freely movable or pivotably coupled to a base. Each arm has three holes. The arms can be moved so as to be adjacent and parallel to each other, such that the holes of the arms emulate the 3 X 2 Braille cell. The arms can also be rotated or pivoted away from each other so as to emulate the 1 X 6 keyboard of a Braille writer. In use, the student places pegs in the holes corresponding to the Braille character requested by the instructor, with each peg corresponding to a raised Braille dot. It is widely known among therapists, teachers, parents, and students that

these pegs can easily be, and often do become, lost. Moreover, it has been found that the conventional swing cell instrument does not afford sufficient motivation for Braille students, and children in particular.

Some commercially available Braille training instruments providing  
5 auditory feedback do exist, but are considered to be too complex or advanced for young children who are just learning to read and write Braille, and/or fail to maintain a sufficient degree of motivation and interest in the learning process. Examples of Braille training instruments that provide a sound output are disclosed in U.S. Patent No. 5,154,614 and 5,902,112. Unlike the swing cell  
10 instrument just described, these feedback-capable instruments cannot be switched between a mode that teaches actual 3 X 2 Braille characters and a mode that teaches the use of the Braille writer keyboard. Moreover, the buttons or keys provided with these instruments fail to provide proper tactile feedback that would be useful in distinguishing between raised and non-raised  
15 Braille dots. For example, in one known device that provides auditory feedback in response to the keying operations of a student, the keys or buttons provided are momentary in nature and thus not capable of maintaining more than one elevation. That is, once a student presses and releases a key, the key immediately pops back up to its original position and thus fails to provide tactile  
20 information regarding the Braille character formed or attempted to be formed by the student.

It would therefore be desirable to provide an apparatus and method for Braille instruction that renders the learning process more enjoyable, interesting and motivational, provides both tactile and auditory stimuli or feedback,

provides instruction in both the formation of Braille-based alphanumeric characters and the use of the keyboard typically employed in manual Braille writers, reduces the degree of oversight required from an instructor, conditions finger movements, and/or provides other advantages.

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### Summary

According to one embodiment, an apparatus is provided for use in instructing a user to communicate in Braille. The apparatus comprises a frame, a plurality of tactile switching devices mounted at the frame, and electronic  
10 circuitry supported by the frame. Each tactile switching device is depressible by the user between a raised position for emulating a raised Braille dot and a lowered position. The electronic circuitry comprises an audio output device. The circuitry communicates with the switching devices for producing an auditory output for emission by the audio output device in response to a  
15 combination of switching devices selectively activated by a user. The auditory output corresponds to the Braille character represented by the combination of activated switching devices.

According to one aspect of this embodiment, the circuitry comprises a control device and a playback device. The control device receives a user input  
20 produced by the combination of switching devices selectively activated by the user, and sends a control signal based on the user input received. The playback device stores a plurality of different auditory outputs, receives the control signal sent from the control device, and sends a selected auditory

output to the audio output device based on the control signal received from the control device.

According to another embodiment, an apparatus is provided for use in instructing a user to communicate in Braille. The apparatus comprises a frame, a plurality of switching devices, a pair of arms, and electronic circuitry. The switching devices can be selectively activated by a user to represent one or more raised Braille dots. The pair of arms are pivotably coupled to the frame. Each arm supports at least three of the switching devices. The pair of arms are rotatable along the frame between a first position at which the arms are generally in parallel relation and the switching devices are arranged in a 3 X 2 array of Braille dots for emulating a Braille cell, and a second position at which the arms are pivoted outwardly from each other in a 1 X 6 row of Braille dots for emulating a Braille writer. The electronic circuitry is supported by the frame and comprises an audio output device. The circuitry communicates with the switching devices for producing an auditory output for emission by the audio output device in response to a combination of switching devices selectively activated by a user. The auditory output corresponds to the Braille character represented by the combination of activated switching devices.

According to yet another embodiment, an apparatus is provided for use in instructing a user to communicate in Braille. The apparatus comprises a frame, a plurality of tactile switching devices, a pair of arms, and electronic circuitry. Each tactile switching device is depressible between a lowered position and a raised position. The pair of arms are pivotably coupled to the frame. Each arm supports at least three of the tactile switching devices. At its

raised position, at least a portion of the switching device is raised above an upper surface of its corresponding arm for emulating a raised Braille dot. The pair of arms are rotatable along the frame between a first position at which the arms are generally in parallel relation and the switching devices are arranged in a 3 X 2 array of Braille dots for emulating a Braille cell, and a second position at which the arms are pivoted outwardly from each other in a 1 X 6 row of Braille dots for emulating a Braille writer. The electronic circuitry is supported by the frame and comprises an audio output device. The circuitry communicates with the switching devices for producing an auditory output for emission by the audio output device in response to a combination of switching devices selectively activated by a user. The auditory output corresponds to the Braille character represented by the combination of activated switching devices.

In a method for instructing a person in communicating in Braille, a plurality of tactile switching devices are provided. Each switching device is actuatable between a raised position that can be sensed by a person as a raised Braille dot and a lowered position that can be sensed as the absence of a raised Braille dot. In response to a combination of switching devices actuated into respective raised positions, an auditory output is provided for the person corresponding to the Braille character represented by the combination of switching devices actuated.

In another method for instructing a person in communicating in Braille, a pair of arms are provided. Each arm supports at least three tactile switching devices. The switching devices can be sensed by touch and selectively actuated for emulating patterns of raised Braille dots. The pair of arms are

rotated between a first position and a second position. At the first position, the arms are generally in parallel relation and the switching devices are arranged in a 3 X 2 array of Braille dots for emulating a Braille cell. At the second position, the arms are pivoted outwardly from each other in a 1 X 6 row of Braille dots for  
5 emulating a Braille writer. In response to a combination of switching devices actuated, an auditory output is provided for the person indicative of a Braille character corresponding to the combination of switching devices actuated.

It is therefore an object to provide an apparatus and method for Braille instruction.

10 An object having been stated hereinabove, and which is addressed in whole or in part by embodiments disclosed herein, other objects will become evident as the description proceeds when taken in connection with the accompanying drawings as best described hereinbelow.

15 Brief Description of the Drawings

Figure 1A is a top perspective view of an apparatus for Braille instruction according to an embodiment disclosed herein, in which the apparatus is in a read mode;

Figure 1B is a top perspective view of the apparatus for Braille  
20 instruction, in which the apparatus is in a write mode;

Figure 2 is a side elevation view of the apparatus for Braille instruction;

Figure 3 is a rear elevation view of the apparatus for Braille instruction;

Figure 4 is a bottom plan view of the apparatus for Braille instruction;

Figures 5A and 5B are respective schematic views of a pushbutton-actuated switch provided with the apparatus for Braille instruction, illustrated in raised and lowered positions;

Figure 6A is a side elevation view of the pushbutton switch;

5 Figure 6B is a bottom plan view of the pushbutton switch;

Figure 7A is a perspective view of a swing arm provided with the apparatus for Braille instruction;

Figure 7B is a partially cutaway side elevation view of the apparatus for Braille instruction, illustrating the swing arm mounted thereto; and

10 Figure 8 is a schematic diagram of electronic circuitry provided with the apparatus for Braille instruction.

#### Detailed Description

As used herein, the term "character" generally means a letter, number,  
15 punctuation mark, abbreviation, pluralities thereof, or combinations thereof.

Referring now to Figures 1A and 1B, an apparatus for instructing persons in reading and writing Braille, generally designated **10**, is illustrated according to one embodiment. Apparatus **10** comprises a frame for mounting or otherwise supporting a plurality of tactile switching devices, generally  
20 designated **TD<sub>1</sub> – TD<sub>6</sub>**; a pair of swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>**; and a suitable audio output component such as a speaker **SP**. In addition, the frame can be employed for mounting and/or enclosing electronic circuitry, generally designated **EC** (see also Figure 8), such as embodied in a printed circuit board

**PCB**, and for mounting controls as described below. In the exemplary embodiment, the frame includes a base **12** on which tactile switching devices **TD<sub>1</sub> – TD<sub>6</sub>** and swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** are disposed, and an enclosure **14** for housing electronic circuitry **EC**. Swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** are pivotably coupled

5 to base **12** at respective pivot axes **PA<sub>1</sub>** and **PA<sub>2</sub>** by any suitable means for enabling swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** to rotatably move on, over or along an upper surface **12A** of base **12**, as generally indicated by arrows in Figure 1B. The terms “on”, “over” and “along” are used interchangeably herein to indicate that, during pivoting, swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** can either slide in contact with upper

10 surface **12A**, or be spaced by a small distance above and thus not actually contact upper surface **12A** other than at the connection made through pivot axes **PA<sub>1</sub>** and **PA<sub>2</sub>**. Pivot axes **PA<sub>1</sub>** and **PA<sub>2</sub>** can represent any means for pivotably coupling swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** to base **12**, such as pins, dowels, screws, bolts or other pivot members **PM** extending into base **12**, as shown by

15 way of example in Figures 7A and 7B.

As indicated above, apparatus **10** comprises a set of tactile switching devices **TD<sub>1</sub> – TD<sub>6</sub>**. Tactile switching devices **TD<sub>1</sub> – TD<sub>6</sub>** are mounted at the frame for manipulation by a user of apparatus **10**. In the advantageous embodiment illustrated herein, apparatus **10** additionally comprises swing arms

20 **SA<sub>1</sub>** and **SA<sub>2</sub>**. Two sets of three tactile switching devices, **TD<sub>1</sub> – TD<sub>3</sub>** and **TD<sub>4</sub> – TD<sub>6</sub>**, are respectively mounted to swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** in a generally linearly spaced-apart relation, for a total of six tactile switching devices **TD<sub>1</sub> – TD<sub>6</sub>**. The sets of tactile switching devices **TD<sub>1</sub> – TD<sub>3</sub>** and **TD<sub>4</sub> – TD<sub>6</sub>** comprise

corresponding sets of pushbuttons **PB<sub>1</sub> – PB<sub>3</sub>** and **PB<sub>4</sub> – PB<sub>6</sub>** for manipulation by the user, and pushbutton switches **SW<sub>1</sub> – SW<sub>3</sub>** and **SW<sub>4</sub> – SW<sub>6</sub>** (see Figures 6A – 8) that are actuable in response to manipulation of respective pushbuttons **PB<sub>1</sub> – PB<sub>3</sub>** and **PB<sub>4</sub> – PB<sub>6</sub>**. Tactile switching devices **TD<sub>1</sub> – TD<sub>6</sub>**, and their  
5    respective pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>** and pushbutton switches **SW<sub>1</sub> – SW<sub>6</sub>** are described in more detail below.

Swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** can be pivoted between a “read” position as shown in Figure 1A and a “write” position as shown in Figure 1B. The read position can be characterized as a “rotated down” position in which swing arms  
10    **SA<sub>1</sub>** and **SA<sub>2</sub>** are vertically oriented (from the perspective of Figure 1A) in parallel and in close adjacency to each other. In the read position, pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>** of tactile switching devices **TD<sub>1</sub> – TD<sub>6</sub>** are arranged in a 3 X 2 array so as to emulate an enlarged Braille cell that can be easily sensed by touch by a student, with each pushbutton **PB<sub>1</sub> – PB<sub>6</sub>** representing a point or dot of the  
15    Braille cell. The write position can be characterized as a “rotated out” position in which swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** are horizontally oriented (from the perspective of Figure 1B), and pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>** are arranged in a single 1 X 6 row so as to emulate the keyboard of a Braille (e.g., Perkins) writing instrument. A peg, dowel, or other protrusion **22** can extend upwardly from  
20    upper surface **12A** of base **12** to provide a stopping mechanism for swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>**. This protrusion **22** limits the extent of pivoting movement of swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** into the read position and maintains the proper position of swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** relative to each other. Similarly, other

protrusions **24A** and **24B** can be mounted to base **12** to provide the stopping/positioning function when pivoting swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** into a write position, respectively. In addition, stops **26A**, **26B** and **28A**, **28B** can be mounted to base **12** as shown in Figures 1A and 1B for contacting any surface  
5 of respective swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** (frictional contact, for example) to assist in retaining swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** in their proper positions.

Referring to Figure 2, in some embodiments, some of the controls for apparatus **10** can be mounted at a lateral side **14A** of enclosure **14**. In the example illustrated in Figure 2, an ON/OFF power switch **32** for apparatus **10**  
10 and an audio output selector switch **34** are mounted at this lateral side **14A**. Audio output selector switch **34** can have two or more settings to enable the selection of different types of auditory outputs or combinations of outputs responsive to a student's manipulation of pushbuttons **PB<sub>1</sub>** – **PB<sub>6</sub>** on swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>**. For example, in response to manipulating pushbuttons **PB<sub>1</sub>**  
15 – **PB<sub>6</sub>** to form the Braille character for the letter "a", audio output selector switch **34** in one position could cause apparatus **10** to playback a pronunciation of the letter "a" through speaker **SP**, and in another position could enable apparatus **10** to play back not only a pronunciation of the letter "a" but also a word beginning with the letter "a" (e.g., "apple") and/or a sound associated with  
20 such word (e.g., <crunch>).

Referring to Figure 3, other controls for apparatus **10** can be mounted at a rear side **14B** of enclosure **14**, i.e., the side of enclosure **14** farthest away from where a student would be sitting. In the example illustrated in Figure 3, a

volume control **36** for speaker **SP** (Figures 1A and 1B), a time delay switch **38**, a record button **42**, a record/playback mode switch **44**, and a suitable auditory input connection such as an audio jack **46** are mounted at rear side **14B**. Volume control **36** controls the gain of the output of speaker **SP**, and preferably  
5 is mounted to rear side **14B** as illustrated so as to discourage the student from adjusting the volume level set by an instructor or parent.

Time delay switch **38** can enable two or more time delay settings for determining the period of time between the occurrence of an audio prompt directed to the student through speaker **SP** and the completion of the student's  
10 response through manipulation of tactile switching devices **TD<sub>1</sub> – TD<sub>6</sub>**, or the period of time between the occurrence of the student's manipulation of tactile switching devices **TD<sub>1</sub> – TD<sub>6</sub>** and the auditory feedback received by the student in response thereto, or the like. For example, time delay switch **38** can be used to switch between an easy setting and a hard setting for the student. In the  
15 easier setting, the student can be given, for example, 500 ms to depress (and release) the combinations of pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>** required to correctly form or write the requested character, and in the hard setting the delay can be reduced to 200 ms. It will be noted that the specific examples just given of values for the time delay were determined by working with certain test cases  
20 including children with impaired and non-impaired motor control, but the embodiments disclosed herein are not limited to any specific values for the time delay settings. The time delay feature is useful for enforcing simultaneous pressing of pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>** by the student, as such is required in the

use of an actual Braille writer. If simultaneous pressing does not occur, electronic circuitry **EC** (Figure 8) of apparatus **10** can be configured to provide an auditory message indicating an incorrect entry (i.e., the combination of pushbuttons **PB<sub>1</sub>** – **PB<sub>6</sub>** depressed by the student does not represent a Braille character) or a message for another letter that was not intended. This allows children, who become accustomed to apparatus **10**, to receive instructional prompts without the need for constant instructor oversight. Time delay switch **38** is preferably mounted to rear side **14B** of enclosure **14** to discourage the student from accidentally switching apparatus **10** into the harder mode, thereby avoiding potential frustration.

Record button **42**, record/playback mode switch **44**, and audio jack **46** are employed to record auditory outputs, such as prompts and/or feedback for the student, into a voice chip **VC** or other suitable sound or voice record/playback device provided with electronic circuitry **EC** (see Figure 8).

Record/playback mode switch **44** can be used to switch electronic circuitry **EC** between recording and playback modes, and record button **42** can be depressed while recording to enable voice chip **VC** to receive and store voice or sound data from an external source. For this purpose, audio jack **46** can be used to provide communication between voice chip **VC** and a microphone **MP** (Figure 8), an external audio playback device (e.g., a CD player), a computer, or other suitable audio input device. Apparatus **10** can be configured to provide an auditory output for emission by speaker **SP** that indicates a change in the setting of record/playback mode switch **44** (e.g., “now in record mode”). Such

auditory outputs can be stored in a memory register included with voice chip **VC**.

A suitable electronic control device such as a microprocessor, microcontroller **MC**, or the like provided with electronic circuitry **EC** (Figure 8) coordinates the output of voice chip **VC** with the input provided by the student (i.e., the operation of pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>** of tactile switching devices **TD<sub>1</sub> – TD<sub>6</sub>**) in either the read or write modes of apparatus **10**. An instructor or parent can select the words and/or sounds to be associated with corresponding Braille characters in response to successful formation of those characters by the student using tactile switching devices **TD<sub>1</sub> – TD<sub>6</sub>**. For example, if the student is prompted to form the letter “c” (either by the instructor or parent, or by the programmed auditory operation of apparatus **10** as controlled by microcontroller **MC**), and the student successfully manipulates tactile switching devices **TD<sub>1</sub> – TD<sub>6</sub>** in the correct pattern or combination, voice chip **VC** will output an appropriate verification through speaker **SP** such as “c . . . cat . . . <meow>”. To maintain a sufficient level of interest and enjoyment in the learning process, the record mode can be employed to change specific auditory feedback responses (e.g., the response for “c” could be changed to “c . . . cricket . . . <chirp>”). Pre-recorded media such as compact disks or software can also be employed for this purpose, by connecting an appropriate playback instrument to audio jack **46**. Moreover, recordings could be made with the student’s own voice and selection of word and/or sound associations to generate further interest in the learning process and the use of apparatus **10**.

As an example of recording auditory outputs into apparatus **10** as feedback for the student during the use of apparatus **10**, an instructor, parent or student manipulates record/playback mode switch **44** to set apparatus **10** into its record mode which, as noted above, can result in an auditory response  
5 such as "now in record mode". With swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** positioned in either the read or the write position, one or more of pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>** are actuated into the raised position in the Braille pattern corresponding to the character (e.g., "a") for which a sound is to be recorded. The actuation of pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>** while in the record mode enables voice chip **VC** or  
10 microcontroller **MC** to identify the memory cell or memory location of voice chip **VC** into which the sound is to be copied. Next, record button **42** is depressed and, while record button **42** is held down, one or more sounds (e.g., a pronunciation of "a", and/or "apple", and/or a sound for "<crunch>") are input into voice chip **VC** via an external device (e.g., microphone **MP**, CD player, or  
15 the like) connected to audio jack **46**. This process is then repeated for other sounds to be recorded (e.g., "b", "c", . . . ; "1", "2", "3", . . . ).

It can be appreciated that, depending on the desired configuration of electronic circuitry **EC**, one memory cell can be used to store all auditory output types of a single association (e.g., "a", "apple", "<crunch>"), or separate  
20 memory cells can be used to store each different type of auditory output associated with a particular character. In the case of using a single memory cells for all associated auditory output types, during the use of apparatus **10** in the playback mode, the setting of audio output selector switch **34** determines

how long voice chip **VC** will play the auditory output stored in the selected memory cell. For instance, if audio output selector switch **34** is set to a "letter only" mode, voice chip **VC** will only play the first portion of the auditory output (e.g., "a") and then stop. If, on the other hand, audio output selector switch **34** is set to a "letter + sound" mode, voice chip **VC** will play the entire recording stored as the selected memory location (e.g., "a", "apple", "<crunch>"). In the case of using different memory cells for different auditory output types, during the use of apparatus **10** in the playback mode, the setting of audio output selector switch **34** determines which memory cell will be accessed and played by voice chip **VC** in response to a particular user input effected through actuation of tactile switching devices **TD<sub>1</sub> – TD<sub>6</sub>**. For instance, if audio output selector switch **34** is set to a "letter only" mode, voice chip **VC** will access and play from the memory cell in which a single letter (e.g., "a") is stored. If, on the other hand, audio output selector switch **34** is set to a "letter + sound" mode, voice chip **VC** will access and play from the memory cell in which all similarly associated auditory outputs are stored (e.g., "a", "apple", "<crunch>").

Referring to Figure 4, an underside **12B** of base **12** is illustrated. In this embodiment, underside **12B** includes a cavity **12C** providing a space for routing conduits **52A** and **52B** containing electrical wiring **54** (see Figures 7A and 7B) from respective swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** mounted on base **12** to electronic circuitry **EC** contained within enclosure **14**. The electrical interface between pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>** of swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** and electronic circuitry **EC** is described in more detail below. A bottom plate or panel (not shown),

constructed of wood, plexiglass or the like, can be mounted to underside **12B** to enclose conduits **52A** and **52B** within cavity **12C**.

In advantageous embodiments, tactile switching devices **TD<sub>1</sub> – TD<sub>6</sub>** are of the "latching" or "alternate action" type as those terms are understood by persons skilled in the art. A simplified illustration of one tactile switching device **TD** of this type is provided in Figures 5A and 5B. As appreciated by persons skilled in the art, pushbutton **PB** can be actuated between an OFF state and an ON state. Pushbutton **PB** is in a raised position while in the OFF state and in a lowered position while in the ON state. A user of apparatus **10** (e.g., a student or instructor) can cycle pushbutton **PB** from the ON state to the OFF state and vice versa by depressing and subsequently releasing pushbutton **PB**. That is, if pushbutton **PB** is in the raised state shown in Figure 5A, depressing and releasing pushbutton **PB** locks pushbutton **PB** into the lowered state shown in Figure 5B. Depressing and releasing pushbutton **PB** once again unlocks pushbutton **PB** and allows it to return to the raised state. Thus, pushbutton **PB** remains in either the raised or lowered position until such time as pushbutton **PB** is deliberately actuated to switch into the other state. In the context of the present embodiment, the raised position of a given pushbutton **PB** corresponding to a coordinate within the Braille cell represents the existence of a raised Braille dot at that coordinate, and the lowered position of pushbutton **PB** represents the absence of a raised Braille dot at that coordinate. For example, referring to Figure 1A or 1B, depressing pushbutton **PB<sub>1</sub>** (corresponding to the top left dot of a Braille cell) into its raised position yields

the Braille character for the letter "a", depressing pushbuttons **PB<sub>1</sub>** and **PB<sub>2</sub>** (corresponding to the top left and middle left dots of a Braille cell) into their raised positions yields the Braille character for the letter "b", and so on. It will be understood that the terms "ON" and "OFF" are used arbitrarily herein as they relate to the raised and lowered positions of pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>**, and are not intended to limit either state of pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>** to a specific logic or binary state.

Referring to Figures 6A and 6B, a structural example of a tactile switching device **TD** is illustrated according to one embodiment. As shown in Figure 6A, the exemplary tactile switching device **TD** includes a nut **62** and housing **64** or similar structure that facilitates mounting tactile switching device **TD** in a corresponding bore formed in swing arm **SA<sub>1</sub>** or **SA<sub>2</sub>**. Mounting can be effected in any suitable manner, such as press-fitting, the use of splines or threads, or the like. In some embodiments, each tactile switching device **TD** can be mounted directly to base **12** in either the 3 X 2 or 1 X 6 arrangement, without the use of swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>**. In advantageous embodiments, however, each tactile switching device **TD** is mounted directly to a corresponding swing arm **SA<sub>1</sub>** or **SA<sub>2</sub>** to provide the ability to use apparatus **10** in either the read or write mode, as described above and illustrated in Figures 1A and 1B.

As also shown in Figures 6A and 6B, in addition to pushbutton **PB**, each tactile switching device **TD** includes a pushbutton switch **SW**. Pushbutton **PB** mechanically communicates with pushbutton switch **SW** in any manner suitable

for enabling pushbutton **PB** to be manipulated by a user to cycle pushbutton switch **SW** between the ON and OFF states. As noted above, in advantageous embodiments, the interface between pushbutton **PB** and pushbutton switch **SW** is such as to realize a latching or alternate action type of design. Referring to

5 Figure 6B, pushbutton switch **SW** can include one or two pairs of conductive pins or other types of terminals **68A**, **68B** and **72A**, **72B**. One pair of terminals **68A** and **68B** are operatively associated with the switching of tactile switching device **TD** between the ON and OFF states. As an option, another pair of terminals **72A** and **72B** can be provided to switch an **LED** (Figure 8) disposed

10 within tactile switching device **TD** for illuminating its corresponding pushbutton **PB**, or disposed remotely from tactile switching device **TD**, such as at a panel mounted on apparatus **10** readily within sight of an instructor or parent. This option can serve as a visual aid for an instructor to provide an enhanced indication of whether pushbutton **PB** is in a raised or lowered position

15 depending on how **LED** is connected. One example of a suitable tactile switching device **TD** or the latching or alternate action type is available as part # EG2543-ND from Digi-Key Corporation, Thief River Falls, Minnesota.

Referring to Figures 7A and 7B, one swing arm **SA<sub>2</sub>** is illustrated in detail, with the understanding that the other swing arm **SA<sub>1</sub>** can be the same or

20 substantially similar in terms of structure and features. In advantageous embodiments, a recess **82** is formed in an underside of swing arm **SA<sub>2</sub>** to facilitate the routing of wiring **54** in a manner enabling swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** to pivot without damaging wiring **54**. Thus, the bottom end of each pushbutton

switch **SW<sub>4</sub> – SW<sub>6</sub>** or at least its terminals **68A**, **68B** and **72A**, **72B** extend into or are exposed to recess **82**, and wiring **54** from each pushbutton switch **SW<sub>4</sub> – SW<sub>6</sub>** is disposed longitudinally along recess **82** toward pivot member **PM<sub>2</sub>**. In the vicinity of pivot member **PM<sub>2</sub>**, wiring **54** is generally coaxially grouped within

5 conduit **52B** adjacent to pivot member **PM<sub>2</sub>**. Conduit **52B** and pivot member **PM<sub>2</sub>** are run through separate, adjacent bores **92** and **94** formed in base **12**, or alternatively are both run through the same bore in base **12**. Conduit **52B** extends through base **12** and is directed into the interior of enclosure **14** for connection to electronic circuitry **EC** by any suitable means. In the example

10 illustrated in Figure 7B, wiring **54** and conduits **52A** (not specifically shown) and **52B** from both swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** terminate at a D-sub male connector **102** for removable connection with a female connector **104** communicating with electronic circuitry **EC** via a ribbon cable **106**.

In Figure 7B, pushbuttons **PB<sub>4</sub> – PB<sub>6</sub>** are shown in the raised position.

15 In one embodiment, the tops of pushbuttons **PB<sub>4</sub> – PB<sub>6</sub>** when in the raised position are elevated 1/8 inch or thereabouts above an upper surface **112** of swing arm **SA<sub>2</sub>**. Other elevation values can be chosen for the raised position, so long as pushbuttons **PB<sub>4</sub> – PB<sub>6</sub>** are capable of providing a raised dot effect that can be easily sensed by the student and distinguished from the lowered

20 position. In one embodiment, while in the lowered position, each pushbutton **PB<sub>4</sub> – PB<sub>6</sub>** is flush or substantially flush with upper surface **112** of swing arm **SA<sub>2</sub>**, thereby clearly indicating the absence of a raised dot at the coordinate of that particular pushbutton **PB<sub>4</sub> – PB<sub>6</sub>**. If desired, swing arm **SA<sub>2</sub>**, or at least its

upper surface **112**, can be covered with a laminate material to provide a smooth surface flush with pushbuttons **PB<sub>4</sub> – PB<sub>6</sub>** while in the lowered position.

Figure 8 schematically illustrates electronic circuitry **EC** included with apparatus **10**. In advantageous embodiments, electronic circuitry **EC** is housed within enclosure **14** (see Figures 1A, 1B and 7B) and mounted, for instance, to a suitable printed board **PCB**. As noted above, electronic circuitry **EC** includes microcontroller **MC** and voice chip **VC**, which communicate with each other by known means. One non-limiting example of a suitable microcontroller **MC** is a 28/40-pin, 8-bit, CMOS-based chip with flash program memory, data memory (RAM) and EEPROM data memory, and a 35-single-word instruction set, which is available as part # PIC16F877-20/P-ND from Digi-Key Corporation. One non-limiting example of a suitable voice chip **VC** is a CMOS-based voice record/playback chip with flash memory and multiple-message and non-volatile multi-level storage capability, which is available as part # ISD4004-08MP-ND from Digi-Key Corporation. As illustrated in Figure 8, microcontroller **MC** receives inputs from pushbutton switches **SW<sub>1</sub> – SW<sub>6</sub>**, audio output selector switch **34**, time delay switch **38**, record button **42**, and record/playback mode switch **44**. In some embodiments, pushbutton switches **SW<sub>1</sub> – SW<sub>6</sub>**, communicate with respective light-emitting diodes **LED<sub>1</sub> – LED<sub>6</sub>** as noted above. Voice chip **VC** has an analog differential input connection **122** that can be capacitively coupled to microphone **MP** or other suitable audio input devices as noted above for receiving auditory input through audio jack **46** (Figure 3). Auditory output from voice chip **VC** is capacitively coupled to volume control **36**,

which is a potentiometer that controls the gain achieved by an LM386 op-amp **124**. The output from op-amp **124** is sent to speaker **SP**. As further shown in Figure 8, a +3V regulator **REG<sub>1</sub>** and a +5V regulator **REG<sub>2</sub>** are provided to supply power to voice chip **VC** and microcontroller **MC**, respectively, from a +9V battery source. As appreciated by persons skilled in the art, electronic circuitry **EC** could be adapted for receiving power from a standard line voltage source as well. All other components and functions of electronic circuitry **EC** as schematically shown in Figure 8 are readily understood by persons skilled in the art, and therefore need not be described further herein.

10           An example of the operation of apparatus **10** will now be described, with the understanding that apparatus **10**, as described above, is highly flexible and reconfigurable such that it can be tailored to a variety of different types of techniques for providing and enhancing the instruction of Braille communication. First, either before or after apparatus **10** is initially powered  
15           up, the user (student, parent, instructor, etc.) ensures that apparatus **10** is set to the proper operating modes. If new pronunciations, sounds, and/or other types of auditory prompts or feedback are to be recorded, record/playback mode switch **44** is set to record mode and the recording techniques described above can then be performed. If no recordings are to be made, apparatus **10**  
20           is set to the playback (i.e., instruction) mode by setting record/playback mode switch **44** to playback mode. In addition, the user selects the type of auditory output (e.g., letter only, letter and word, letter and word and sound) to be emitted from speaker **SP** by setting audio output selector switch **34**

appropriately. At this time, volume and time delay settings can also be made using volume control **36** and time delay switch **38**, respectively. Also, the read or write mode for apparatus **10** is selected, and swing arms **SA<sub>1</sub>** and **SA<sub>2</sub>** are rotated as necessary to set apparatus **10** into the position corresponding to the  
5 selected mode.

Once apparatus **10** has been set up as described above, a Braille instructive session can be initiated, during which time any input made by the student via manipulation of pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>** (and thus pushbutton switches **SW<sub>1</sub> – SW<sub>6</sub>**) will result in an appropriate auditory output sounded  
10 through speaker **SP**. Apparatus **10** can be adapted for use in connection with any type of prompt for the student to make a user input. For instance, an instructor or parent can provide the prompts, such as by requesting that the student form a certain character using pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>**. Alternatively, the instructor or parent can play a recording from an external device (e.g., a  
15 CD player) that provides a series of prompts (i.e., a predetermined lesson) for the student (e.g., "now please type the letter 'a'"), with a sufficient amount of time transpiring between each prompt to allow the student to manipulate pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>** in response to the prompt and to receive the resulting auditory output from speaker **SP**. In addition, apparatus **10** can be configured  
20 such that prompts are stored and played by voice chip **VC**, as well as the auditory outputs, all of which can be controlled by microcontroller **MC**. Finally, apparatus **10** can be used without any external prompts or predetermined lessons, enabling the student to engage in self-practice and exploration.

In the operation of electronic circuitry, manipulation of one or more pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>** of tactile switching devices **TD<sub>1</sub> – TD<sub>6</sub>** into the raised position results in activation of one or more corresponding pushbutton switches **SW<sub>1</sub> – SW<sub>6</sub>**. This user input results in one or more input signals being sent

5 over wiring **54** (Figure 7B) to microcontroller **MC**. If microcontroller **MC** interprets the received user input as corresponding to a digital value representing a particular Braille character, microcontroller **MC** sends a control signal or other appropriate electronic output to voice chip **VC**, after expiration of the time delay delimited by time delay switch **38**, as necessary to access the

10 memory cell in voice chip **VC** containing the auditory output corresponding to the intended Braille character. In response, voice chip **VC** plays the auditory output, of the type delimited by audio output selector switch **34**, through speaker **SP** to provide verification to the student that the student has correctly formed the intended Braille character using pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>**. If, after

15 expiration of the time delay, microcontroller **MC** fails to recognize the user input as corresponding to a particular Braille character, microcontroller **MC** can be adapted to cause voice chip **VC** to play an auditory output indicative of this error. Electronic circuitry **EC** can be configured to be reset in response to receiving a user input generated by returning all pushbuttons **PB<sub>1</sub> – PB<sub>6</sub>** to the

20 lowered position.

It will be understood that various details of the invention may be changed without departing from the scope of the invention. Furthermore, the foregoing description is for the purpose of illustration only, and not for the

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purpose of limitation, as the invention is defined by the claims as set forth hereinafter.